

**CLEAN VERSION OF CLAIMS**

## CLAIMS

- 1 1. An apparatus adapted for seismic data acquisition in a land or transition  
2 zone environment, said apparatus comprising:  
3 a positioning device;  
4 a seismic sensor, capable of being placed near said positioning device;  
5 and  
6 means for determining the distance between said seismic sensor and said  
7 positioning device using an airborne acoustic transmission between said  
8 positioning device and said seismic sensor.
  
- 1 2. An apparatus as claimed in claim 1, in which said airborne acoustic  
2 transmission is produced by a speaker at said positioning device and  
3 received by a microphone at said seismic sensor.
  
- 1 3. An apparatus as claimed in claim 2, in which said airborne acoustic  
2 transmission received by said microphone at said seismic sensor is  
3 converted from analog to digital format using an analog to digital  
4 converter that is also used to convert seismic signals received by said  
5 seismic sensor from analog to digital format.

- 1 4. An apparatus as claimed in either claim 2 or claim 3, in which said
- 2       airborne acoustic transmission received by said microphone at said
- 3       seismic sensor is transmitted using a cable that is also used to transmit
- 4       seismic data received by said seismic sensor.
  
- 1 5. An apparatus as claimed in any one of claims 1 to 4, in which said
- 2       airborne acoustic transmission is a spread spectrum acoustic signal.
  
- 1 6. An apparatus as claimed in any one of claims 1 to 5, in which said
- 2       airborne acoustic transmission is a pulse, frequency sweep, or digitally
- 3       encoded sweep acoustic signal.
  
- 1 7. An apparatus as claimed in any one of claims 1 to 6, in which said
- 2       airborne acoustic transmission is generated by signal generation circuitry
- 3       that is also used to test said seismic sensor.
  
- 1 8. An apparatus as claimed in any one of claims 1 to 7, further including a
- 2       temperature sensor for measuring the temperature of the air near said
- 3       seismic sensor or said positioning device.
  
- 1 9. An apparatus as claimed in any one of claims 1 to 8, further including a
- 2       survey flag and wherein said positioning device is placed near said
- 3       survey flag.

- 1 10. An apparatus as claimed in any one of claims 1 to 9, in which said
- 2 positioning device is a first positioning device and further including a
- 3 second positioning device and means for determining the distance
- 4 between said second positioning device and said seismic sensor using an
- 5 airborne acoustic transmission between said second positioning device
- 6 and said seismic sensor.
  
- 1 11. An apparatus as claimed in claim 10, further including means for
- 2 determining the distance between said first positioning device and said
- 3 second positioning device.
  
- 1 12. An apparatus as claimed in claim 11, in which said means for
- 2 determining the distance between said first positioning device and said
- 3 second positioning device uses an airborne acoustic transmission
- 4 between said first positioning device and said second positioning device.
  
- 1 13. An apparatus as claimed in any one of claims 10 to 12, in which said first
- 2 positioning device and said second positioning device are connected by a
- 3 cable.
  
- 1 14. An apparatus as claimed in any one of claims 10 to 13, in which said
- 2 second positioning device is placed at a predetermined azimuthal
- 3 orientation with respect to said first positioning device.

1 15. An apparatus as claimed in any one of claims 10 to 14, further including  
2 means for confirming that said second positioning device has been placed  
3 at a predetermined azimuthal orientation with respect to said first  
4 positioning device.

1 16. An apparatus as claimed in any one of claims 10 to 15, in which a  
2 seismic source signal is used to determine to resolve the line symmetry  
3 ambiguity when determining the position of said seismic sensor with  
4 respect to said first positioning device and said second positioning  
5 device.

1 17. An apparatus as claimed in claim any one of claims 1 to 16, wherein said  
2 seismic sensor is a first seismic sensor and further including additional  
3 seismic sensors and means for determining the distance between said  
4 additional seismic sensors and said positioning device using airborne  
5 acoustic transmission between said positioning device and said additional  
6 seismic sensors.

1 18. An apparatus as claimed in claim 17, further including means for  
2 calculating a group center of gravity for said first seismic sensor and said  
3 additional seismic sensors.

- 1 19. An apparatus as claimed in claim 17, further including means for
- 2 determining whether said first seismic sensor and said additional seismic
- 3 sensors have been laid out in a prescribed order.
  
- 1 20. An apparatus as claimed in any one of claims 1 to 19, in which said
- 2 seismic sensor and said positioning device are located at a first seismic
- 3 station and further including an additional positioning device located at a
- 4 second seismic station and means for determining the distance between a
- 5 device located at said first seismic station and a device located at said
- 6 second seismic station.
  
- 1 21. A method of determining the position of a seismic sensor adapted for
- 2 seismic data acquisition in a land or transition zone environment, said
- 3 method comprising the steps of:
- 4 placing a positioning device in a particular location;
- 5 placing a seismic sensor near said positioning device; and
- 6 determining the distance between said seismic sensor and said
- 7 positioning device using an airborne acoustic transmission between said
- 8 positioning device and said seismic sensor.
  
- 1 22. A method as claimed in claim 21, in which said airborne acoustic
- 2 transmission is produced by a speaker at said positioning device and
- 3 received by a microphone at said seismic sensor.

- 1 23. A method as claimed in claim 22, in which said airborne acoustic
- 2 transmission received by said microphone at said seismic sensor is
- 3 converted from analog to digital format using an analog to digital
- 4 converter that is also used to convert seismic signals received by said
- 5 seismic sensor from analog to digital format.
  
- 1 24. A method as claimed in either claim 22 or claim 23, in which said
- 2 airborne acoustic transmission received by said microphone at said
- 3 seismic sensor is transmitted using a cable that is also used to transmit
- 4 seismic data received by said seismic sensor.
  
- 1 25. A method as claimed in any one of claims 21 to 24, in which said
- 2 airborne acoustic transmission is a spread spectrum acoustic signal.
  
- 1 26. A method as claimed in any one of claims 21 to 25, in which said
- 2 airborne acoustic transmission is a pulse, frequency sweep, or digitally
- 3 encoded sweep acoustic signal.
  
- 1 27. A method as claimed in any one of claims 21 to 26, in which said
- 2 airborne acoustic transmission is generated by signal generation circuitry
- 3 that is also used to test said seismic sensor.

- 1 28. A method as claimed in any one of claims 21 to 27, further including the
- 2 step of measuring the temperature of the air near said seismic sensor or
- 3 said positioning device.
  
- 1 29. A method as claimed in any one of claims 21 to 28, in which said
- 2 positioning device is placed near a survey flag.
  
- 1 30. A method as claimed in any one of claims 21 to 29, in which said
- 2 positioning device is a first positioning device and further including the
- 3 step of determining the distance between a second positioning device and
- 4 said seismic sensor using an airborne acoustic transmission between said
- 5 second positioning device and said seismic sensor.
  
- 1 31. A method as claimed in claim 30, further including the step of
- 2 determining the distance between said first positioning device and said
- 3 second positioning device.
  
- 1 32. A method as claimed in claim 31, in which said step of determining the
- 2 distance between said first positioning device and said second
- 3 positioning device uses an airborne acoustic transmission between said
- 4 first positioning device and said second positioning device.

1 33. A method as claimed in any one of claims 30 to 32, in which said first  
2 positioning device and said second positioning device are connected by a  
3 cable.

1 34. A method as claimed in any one of claims 30 to 33, in which said second  
2 positioning device is placed at a predetermined azimuthal orientation  
3 with respect to said first positioning device.

1 35. A method as claimed in any one of claims 30 to 34, further including the  
2 step of confirming that said second positioning device has been placed at  
3 a predetermined azimuthal orientation with respect to said first  
4 positioning device.

1 36. A method as claimed in any one of claims 30 to 35, in which a seismic  
2 source signal is used to determine to resolve the line symmetry ambiguity  
3 when determining the position of said seismic sensor with respect to said  
4 first positioning device and said second positioning device.

1 37. A method as claimed in any one of claims 21 to 35, wherein said seismic  
2 sensor is a first seismic sensor and further including additional seismic  
3 sensors and the step of determining the distance between said additional  
4 seismic sensors and said positioning device using airborne acoustic

5                   transmissions between said positioning device and said additional  
6                   seismic sensors.

1   38.   A method as claimed in claim 37, further including the step of calculating  
2                   a group center of gravity for said first seismic sensor and said additional  
3                   seismic sensors.

1   39.   A method as claimed in claim 37, further including the step of  
2                   determining whether said first seismic sensor and said additional seismic  
3                   sensors have been laid out in a prescribed order.

1   40.   A method as claimed in any one of claims 21 to 39, in which said seismic  
2                   sensor and said positioning device are located at a first seismic station  
3                   and further including an additional positioning device located at a second  
4                   seismic station and the step of determining the distance between a device  
5                   located at said first seismic station and a device located at said second  
6                   seismic station.

1   41.   A method as claimed in any one of claims 21 to 40, further including the  
2                   steps of recording seismic data acquired by said seismic sensor and  
3                   assigning sensor position coordinates to said seismic data based on said  
4                   distance between said seismic sensor and said positioning device.

- 1 42. A method as claimed in any one of claims 21 to 41, further including the
- 2 step of calculating a deviation between actual seismic sensor position
- 3 coordinates and planned seismic sensor position coordinates.
  
- 1 43. A method as claimed in claim 42, further including the step of
- 2 compensating for said deviation between said actual seismic sensor
- 3 position coordinates and said planned seismic sensor position
- 4 coordinates.
  
- 1 44. A method as claimed in claim 43, in which said compensation step
- 2 includes mathematically moving a group center of gravity from an actual
- 3 position to a planned position.
  
- 1 45. A method as claimed in claim 44, in which said compensation step
- 2 includes bypassing a digital ground roll removal process.